Title

Airspring Sleeve

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Reference to Related Applications

This application claims priority from U.S. provisional application serial number 60/407,361 filed August 30, 2002.

Field of the Invention

10   The invention relates to an air spring and more particularly to an air spring sleeve having at least two plies, each ply having a cord differential helix angle wherein an inner cord helix angle is greater than an outer cord helix angle.

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Background of the Invention

Air springs generally comprise a piston and an endcap with an elastomer sleeve connected in an airtight manner between them. The sleeves may comprise cords embedded in

20   the elastomer body. The cords are wound at a helix angle with respect to a sleeve centerline. The helix angle for each flexible member cord is substantially equal. Equal helix angles contribute to torsional strain and premature failure in air spring sleeves.

25   Composite sleeves are also known. They comprise a sleeve having a first flexible member connected in a partially overlapping manner to a second flexible member. Each flexible member having a different cord helix angle. The inner flexible member having a cord helix angle less

30   that an outer flexible member cord helix angle with respect to a sleeve centerline.

Representative of the art is U.S. patent no. 5,975,
506 (1999) to Thurow et al. which discloses an air spring
having a composite flexible member in which cords are
embedded as a reinforcement. The cord angle (a) in the
5   first flexible-member is different from the cord angle β in
the second flexible-member component. Cord angle (a) is
less than cord angle β.

What is needed is an air spring sleeve having little
or no torsional strain. What is needed is an air spring
10   sleeve having a cord helix angle differential wherein the
inner cord helix angle is greater than an outer cord helix
angle. The present invention meets these needs.

Summary of the Invention

15   The primary aspect of the invention is to provide an
air spring sleeve having little or no torsional strain.

Another aspect of the invention is to provide an air
spring sleeve having a cord helix angle differential
wherein the inner cord helix angle is greater than an outer
20   cord helix angle.

Other aspects of the invention will be pointed out or
made obvious by the following description of the invention
and the accompanying drawings.

The invention comprises an air spring sleeve. The
25   sleeve comprises an elastomer body having two plies. Each
ply comprises a cord embedded in the elastomer body. Each
cord is wound about the sleeve in an opposing direction
from the other and each having a helix angle. The first
cord helix angle and the second cord helix angle comprise a
30   cord differential helix angle. The first or inner cord
helix angle is greater than a second or outer cord helix

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angle. The cord differential helix angle is in the range
of approximately 0° to 2.5°.

<u>Brief Description of the Drawings</u>

5   The accompanying drawings, which are incorporated in
and form a part of the specification, illustrate preferred
embodiments of the present invention, and together with a
description, serve to explain the principles of the
invention.

10   Fig. 1 is a cross-sectional view of an air spring.

Fig. 2 is a detail of a sleeve at A-A in an uninflated
state.

Fig. 3 is a detail of a sleeve at A-A in an inflated
state.

15   Fig. 4 is a graph depicting torsional strain in air
spring sleeves having a high cord differential helix angle.

Fig. 5 is a graph depicting torsional strain in air
spring sleeves having a preferred cord differential helix
angle.

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<u>Detailed Description of the Preferred Embodiment</u>

Fig. 1 is a cross-sectional view of an air spring. Air
spring 100 generally comprises sleeve 103. Sleeve 103 is
connected at each end to endcap 101 and piston 102. Sleeve

25 103 is constructed of two plies 103a and 103b vulcanized
together.

As the air spring is compressed a rolling lobe 104 is
formed. The rolling lobe 104 rolls along an outer surface
102a of piston 102 as the piston moves relative to the

30 endcap.

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Fig. 2 is a detail at A-A of a sleeve in an uninflated state. Ply 103a is an inner ply disposed inward toward an airspring interior I. Ply 103b is an outer ply disposed outward of an airspring interior I as compared to ply 103a. Each ply 103a and 103b comprises a cord 200 and 201 respectively, embedded in an elastomer body. The elastomer material may comprise a natural or synthetic rubber, or a combination thereof. Cords 200 and 201 comprise aramid having a 1000 denier. Cords 200 and 201 may also comprise nylon and polyester, as well as any other textile reinforcements known in the art, and combinations of two or more of the foregoing.

The technique of building on a mandrel generally comprises building a preform on a cylindrical mandrel having two plies of unidirectional cords wound upon an elastomer layer. The cords are spirally wound about the sleeve preform at what is referred to as a helix angle. The ply cords 200, 201 are wound in opposite wrap directions. The sleeve is then vulcanized using methods known in the art. More particularly, cords 200 and 201 describe a helix angle θ with respect to a sleeve centerline CL. Cord 200 is wound first with helix angle θ_1. Cord 201 is wound over cord 200 with a helix angle θ_2 in an opposite direction.

An important aspect of the quality of a vehicle ride derived from using air springs in the suspension is termed harshness. Prior art air springs have a relatively higher harshness due to a phenomenon wherein at the beginning of the compression stroke the air spring tends to momentarily rotate about a major axis, axis CL in the instant case see Fig. 1. More particularly, as the air spring is compressed

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the air spring will tend to rotate about the compression axis as it attempts to move axially. This tendency is most pronounced during initial application of an impulse by a vehicle suspension to the airspring. The tendency to

5   initially rotate momentarily impedes the air spring's ability to compress axially. This initial rotation tendency manifests as a momentarily elevated spring rate, which causes an elevated resistance to axial movement resulting in a momentary inability accommodate a suspension

10 movement or impulse. As such, this tendency contributes to the harshness of the ride. It has been found that equivalent helix angles in air spring plies cause this behavior, as well as increased torsional strain. This behavior leads to premature failure of the air spring

15 sleeve, particularly those having aramid cords. Using plies having a helix angle differential as in the instant invention significantly reduces or eliminates such torsional strain, reduces harshness and increases operating life.

20   The helix angle controls the inflated diameter and length of the inflated air spring. Prior art sleeves comprise helix angles that are equal, namely, helix angle θ_1 is equal to helix angle θ_2. The helix angle for each ply is generally in the range of approximately 25° to 48°.

25   In the inventive sleeve, helix angle θ_2 of ply 103b is less than helix angle θ_1 of ply 103a, resulting in a helix angle differential, $\Delta\theta$, between the ply cords in the sleeve, namely:

$$\theta_2 < \theta_1$$

30   This relationship causes a significant reduction or elimination of a torsional strain in the sleeve, as well as

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a significant reduction in harshness. The torsional strain reduction is optimized when the helix angle differential is in the range of approximately 2.5° to 0°, namely:

$$\approx 2.5° \geq \Delta\theta > 0°$$

5 The torsional strain reduction is not realized for helix angle differentials exceeding approximately 5°.

Further, it has been observed that when the helix angle of ply 103b exceeds the helix angle of ply 103a, or;

$$\theta_2 > \theta_1$$

10 a torsional stress in the sleeve is significantly increased, leading to significantly increased harshness and premature failures.

Fig. 3 is a detail at A-A of a sleeve in an inflated state. As the air spring inflates the helix angle for the 15 first ply and the second ply with respect to an air spring centerline will change, however the helix angle differential as described herein does not significantly change.

Fig. 4 is a graph depicting torsional strain in air 20 spring sleeves having a high cord differential helix angle. Torsional strain is defined as the relative rotational motion of piston 102 as compared to endcap 101. More particularly, if during a compression or extension stroke piston 102 partially rotates about an air spring centerline 25 CL with respect to endcap 101, such relative partial rotation between piston 102 and endcap 101 is referred to as torsional strain. For example, zero torsional strain indicates no relative partial rotation between the piston 102 and endcap 101.

30 Fig. 4 shows a torsional strain for exemplary sleeves A, B, and C.

The helix angle for each ply in each case is:

Helix Angle	θ_1	θ_2	$\Delta\theta$
A,B,C	40°	45°	5°

The differential helix angel $\Delta\theta$ for each exemplary sleeve in the graph is approximately 5°.

The negative torsional strain values are for a compression stroke and the positive torsional strain values are for an extension stroke. The stroke is approximately 75mm in each case.

In examples A, B, and C the helix angle relationship is:

$$\theta_2 > \theta_1$$

In each of these cases the sleeve had significant torsional strain, in each case in excess of 1°.

Fig. 5 is a graph depicting torsional strain in air spring sleeves having a preferred cord differential helix angle. Each of the exemplary cases shown in Fig. 5 has a helix angle relationship:

$$\theta_2 < \theta_1$$

The helix angle for each ply in each sleeve is:

Helix Angle	θ_1	θ_2	$\Delta\theta$
A,B,C,D,E,F	41°	39°	2°

The differential helix angel $\Delta\theta$ for each exemplary sleeve in the graph is approximately 2°. The negative torsional strain values are for a compression stroke and the positive torsional strain values are for an extension stroke. The stroke is approximately 75mm in each case.

One can see in Fig. 5 that the torsional strain for each sleeve is significantly reduced, to approximately 0.15°. This represents a significant decrease in torsional

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strain and harshness, thereby increasing an operational life.

Although a single form of the invention has been described herein, it will be obvious to those skilled in the art that variations may be made in the construction and relation of parts without departing from the spirit and scope of the invention described herein.